



Multivariate analysis of variable importance in the scaling up of electrodialytic remediation of heavy metals from harbour sediments

Pedersen, Kristine B.; Ottosen, Lisbeth M.; Jensen, Pernille Erland; Lejon, Tore

Published in:
Proceedings of the 13th Symposium on Electrokinetic Remediation

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Pedersen, K. B., Ottosen, L. M., Jensen, P. E., & Lejon, T. (2014). Multivariate analysis of variable importance in the scaling up of electrodialytic remediation of heavy metals from harbour sediments. In *Proceedings of the 13th Symposium on Electrokinetic Remediation* (pp. 77-78)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Nº REF.: O325**Multivariate analysis of variable importance in the scaling up of electrodialytic remediation of heavy metals from harbour sediments****Kristine B. Pedersen^{a,*}, Lisbeth M. Ottosen^b, Pernille E. Jensen^b, Tore Lejon^a,**^a *Department of Chemistry, The Arctic University of Norway, 9019 Tromsø, Norway*^b *Arctic Engineering and Sustainable Solutions, Technical University of Denmark, 2800 Kgs Lyngby, Denmark***Corresponding author: kristine.b.pedersen@uit.no*

Large amounts of polluted sediments are annually dredged around the world in order to meet the demands of harbour development and/or to meet governmental acts to improve the aquatic environment of harbours. The most common way of dealing with dredged contaminated sediments is disposal at licensed landfills (land/deep sea), and in some cases solidification/stabilisation of the sediments, e.g. in new harbour constructions. The focus on treatment possibilities of the dredged polluted sediments prior to potential re-use has been limited. With the general focus of developing sustainable societies in which the amount of waste is reduced considerably, a bigger emphasis on identifying and developing methods for removing pollutants from dredged polluted sediments prior to recycling these, e.g. in construction materials, may be expected in the future. Electrodialytic remediation (EDR) provides a method that has been proven to successfully remove heavy metals from polluted harbour sediments in laboratory scale – removing up to 98% of the initial heavy metal concentration and meeting international recommendations from OSPAR [1-7].

The focus of this study was to contribute in the further development of the EDR method for future scaling up. Three different set-ups were tested – two on laboratory scale and one on bench-scale. The EDR set-ups in laboratory scale were the traditional three compartment cells and the newly developed two compartment cells. In the three compartment cells ion exchange membranes separate the sediment in suspension in the middle compartment from the electrodes and circulating electrolytes at the end compartments to prevent the produced proton and hydroxyl ions produced at the electrodes from entering the compartment with the suspension. Water splitting at the anion exchange membrane ensures the acidification of the sediment [8]. In the two compartment cells the anode is placed directly into the compartment with the sediment in suspension and the separated cathode compartment is maintained to prevent hydroxyl ions produced at the cathode from disturbing the remediation process in the compartment with the sediment in suspension. The EDR set-up on bench scale was based on separating the sediment suspension from the electrodes and circulating electrolytes. The sediment suspension was continually circulated through a system of consecutive compartments separated by anion and cation exchange membranes; the electrodes were placed at each end of the stack.

The targeted heavy metals in the study were chromium, copper, nickel, lead and zinc, since elevated concentrations of these heavy metals were found in the sediments. A preliminary laboratory scale screening of the experimental variables showed a relative variable importance in the order remediation time>current density>cell set-up>>stirring rate>liquid-solid ratio>light. Based on these results a multivariate experimental design

was applied to determine the relative importance of the variables: remediation time, current density, type of sediment and type of EDR equipment (2-compartment cell, 3-compartment cell, stack). Two types of polluted harbour sediments were used – one from Hammerfest harbour in the Arctic region of Norway and one from Sisimiut harbour in Greenland. Measurements of the metals aluminium, barium, calcium, iron, potassium, magnesium, manganese, sodium and vanadium were made as indications of the changes EDR may have on the sediment matrix.

Multivariate analysis of the results revealed the variable importance in the experimental space. This was done by performing projection to latent structures (PLS) in which relations between two matrices; X consisting of the experimental variables and Y consisting of the responses, i.e. the remediation levels of the targeted heavy metals and metals naturally occurring in the sediments were determined. The PLS analysis determines whether the variation in the experimental variables are related to the variation in the remediation levels.

The PLS analysis showed that the relative importance of remediation time, current density, EDR equipment and type of sediment were similar in magnitude hence having a similar affect on the remediation process. The highest remediation levels were found when using the two compartment cell set-up. The measurements of naturally occurring metals in the sediments indicated that the 2-compartment cell induced the biggest disturbance to the sediment matrix. Comparing the laboratory scale set-ups with the bench scale set-up showed that more heavy metals per mass of sediment were removed in the EDR cells, however the EDR stack can contain and remediate larger volumes of sediment. The results can be used as basis for future optimisation of the scaling up of the EDR method.

References

- [1] G. Nystroem, L. Ottosen, A. Villumsen, *Sep. Sci. Technol.*, 40 (2005) 2245-2264.
- [2] G.M. Nystroem, L.M. Ottosen, A. Villumsen, *Environ. Sci. Technol.*, 39 (2005) 2906-2911.
- [3] G.M. Nystroem, A.J. Pedersen, L.M. Ottosen, A. Villumsen, *Sci. Total Environ.*, 357 (2006) 25-37.
- [4] K.H. Gardner, G.M. Nystroem, D.A. Aulisio, *Environ. Eng. Sci.*, 24 (2007) 424-433.
- [5] G.M. Kirkelund, L.M. Ottosen, A. Villumsen, *J. Hazard. Mater.*, 169 (2009) 685-690.
- [6] G.M. Kirkelund, L.M. Ottosen, A. Villumsen, *Chemosphere*, 79 (2010) 997-1002.
- [7] L.M. Ottosen, G.M. Nystrom, P.E. Jensen, A. Villumsen, *J. Hazard. Mater.*, 140 (2007) 271-279.
- [8] H.K. Hansen, L.M. Ottosen, B.K. Kliem, A. Villumsen, *J. Chem. Technol. Biotechnol.*, 70 (1997) 67-73.